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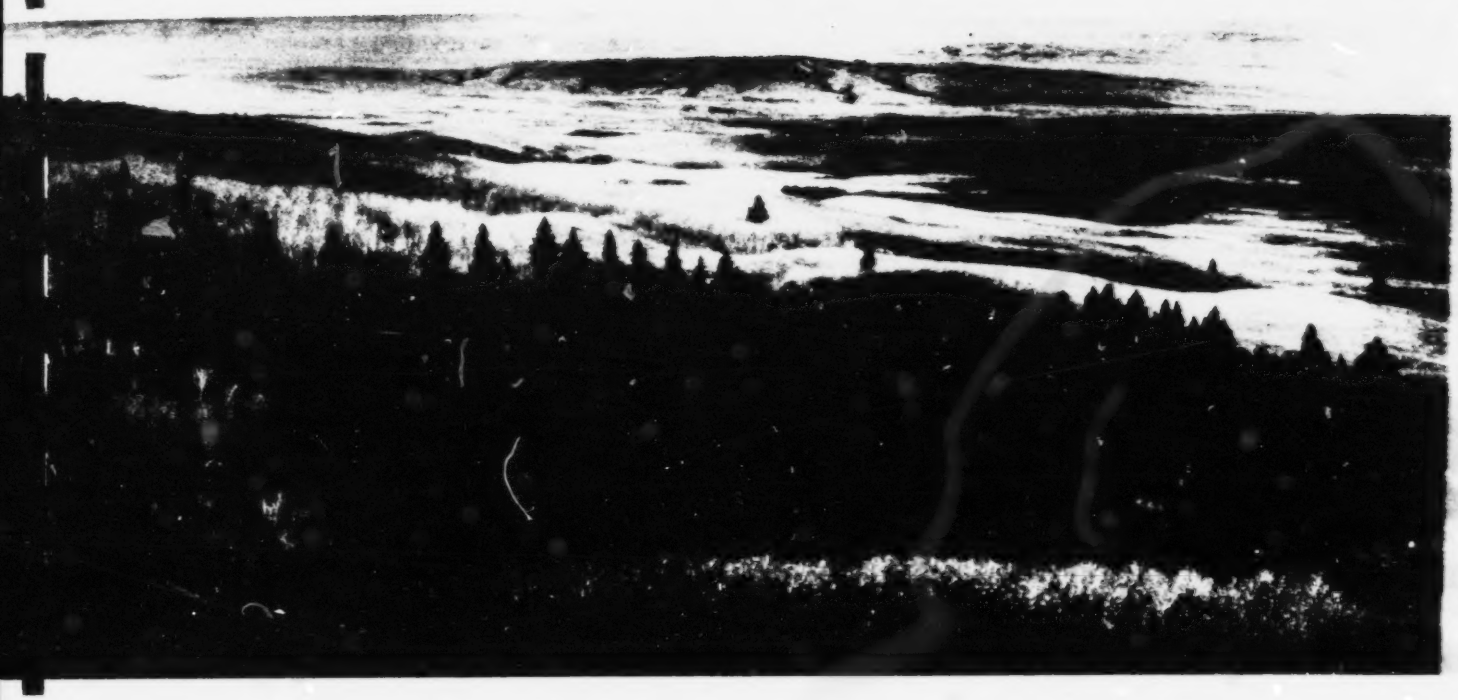
Southern Limit of Coniferous Trees on the Canadian Prairies

by S. C. Zoltai

Information Report NOR-X-128
February, 1975



northern forest research centre
edmonton, alberta

SOUTHERN LIMIT OF CONIFEROUS TREES ON THE CANADIAN PRAIRIES

By

S.C. Zoltai

INFORMATION REPORT NOR-X-128
FEBRUARY, 1975

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ABSTRACT

The southernmost natural distribution of white spruce (Picea glauca), *black spruce* (Picea mariana), *tamarack* (Larix laricina), *jack pine* (Pinus banksiana) *and lodgepole pine* (Pinus contorta) *was determined by field survey. On this basis a narrow transitional zone is defined between the Boreal Forest and the Aspen Parkland. The location and habitats occupied by these coniferous species suggest that rapid changes have not taken place in the distribution of these species in the Prairie region during the last century.*

RESUME

L'auteur releva sur le terrain la répartition naturelle extrême sud (au nord des Prairies) de l'Epinette blanche (Picea glauca), *l'Epinette noire* (Picea mariana), *le Mélèze* (Larix laricina), *le Pin gris* (Pinus banksiana) *et le Pin de Murray ou lodgepole* (Pinus cortorta). *D'après les résultats obtenus, il définit une étroite zone transitoire entre la forêt boréale et la forêt-parc de Trembles. Les stations et habitats de ces résineux font penser qu'aucun changement rapide ne se produisit dans la répartition de ces espèces dans la région des Prairies depuis un siècle.*

INTRODUCTION

The natural vegetation in the southern part of the Canadian Prairies forms two broad vegetation regions, the Grasslands and the Boreal Forest (Rowe 1972). The Grasslands are treeless areas dominated by grasses, with local shrubs (Weaver and Fitzpatrick 1934). The Boreal Forest is characterized by coniferous tree species, especially white and black spruce (*Picea glauca* (Moench) Voss and *P. mariana* (Mill.) B.S.P.). Between these two regions lies a mosaic of grassland and forest, the Aspen Parkland (Bird 1961).

The areal extent of various vegetation regions has undergone changes both in geologic times (Mott 1973), chiefly in response to changing climatic conditions, and in historic times when the actions of man were added to the natural trends.

The existing information on the distribution of coniferous tree species is presented either on very small-scale maps (Anon. 1969, Hosie 1969, Little 1971) or in a generalized form (Rowe 1972). The small scale of these maps precludes the accurate portrayal of the distribution of the trees. This report therefore presents the most southerly natural occurrence of the main coniferous tree species: white spruce, black spruce, tamarack (*Larix laricina* (Du Roi) K. Koch), jack pine (*Pinus banksiana* Lamb.), and lodgepole pine (*P. contorta* Dougl. var. *latifolia* Engelm.). Balsam fir (*Abies balsamea* (L.) Mill.) and eastern white cedar (*Thuja occidentalis* L.) were not included in this study, although they may occur in association with the other conifers in certain areas.

These maps provide a permanent record against which any future changes, natural or man-made, may be checked. They also define

the boundary zone between the Boreal Forest and the Aspen Parkland at this point in time, the last quarter of the 20th century.

METHODS

The approximate southern distribution of coniferous trees in the Prairie Provinces was determined from existing records and from current aerial photographs. A field survey was laid out crossing this approximate boundary at right angles. The vehicle survey proceeded from areas without conifers until all four coniferous tree species were located. The transect lines were about 6.5 km (4 miles) apart where a complete road grid existed, but in areas of poor access all roads were traversed. At about 40-km (25-mile) intervals a deep penetration was made into the Parkland to ascertain the absence of conifer outliers.

The survey was terminated at Bow River, west of Calgary in southern Alberta, because the high foothills restricted the occurrence of some species and introduced new environmental variables. However, the major outliers at Cypress Hills on the Alberta-Saskatchewan boundary and in the Sprucewoods in southern Manitoba were included in the survey.

At each sighting in the field the species was ascertained by examining the morphological characteristics of the tree. The trees were further examined for evidence of planting: e.g. several trees in a row, conifers associated with exotic species, or locations near farmsteads or in fencerows. If the tree was of natural origin, the soil texture and moisture regime were determined by soil pit or probe. The ages of a few trees were determined by increment coring. Each location was entered on a 1:250,000 map and later transferred to a summary map at a scale of 1:2,000,000.

RESULTS

The southernmost occurrences of the various coniferous tree species form a remarkably smooth line on a small scale map (Maps 1, 2, 3 and 4). In general, white spruce is encountered first when proceeding northward from the Aspen Parkland. Tamarack is usually the next coniferous species found, often in association with black spruce, and pine is generally the last conifer to appear. In many areas, however, all conifers are encountered within a very short distance. The width of this transitional zone, where one or more but not all coniferous species occur, varies from 3 km (2 miles) to 107 km (67 miles) as shown on Map 5.

Outliers of coniferous species were identified on the maps if these were located at a considerable distance from other occurrences. A black spruce outlier, reported from the Sprucewoods area of Manitoba (Bird 1927), was not checked during this survey, so it is not shown on the map. No attempts were made to identify inliers of the Aspen Parkland (e.g. areas without coniferous trees) inside the range of the conifers.

Absolute accuracy is not claimed for the results of this survey. Time and distance limitations restricted the survey to a grid of roads; in some areas very limited access was possible by land vehicle. A brief check of a 160-km (100-mile) segment of the boundary by aerial reconnaissance in central Saskatchewan showed only two occurrences that were missed by the road survey. Both of these were less than 5 km (3 miles) from occurrences located on the ground.

In the course of the survey it was recognized that some species such as black spruce were restricted to a specific environment. On the other hand, other species, such as white spruce, grew on a variety of sites, as shown in the following generalized remarks.

WHITE SPRUCE (MAP 1)

White spruce was found on all soil materials from peat and sand to clay of lacustrine, fluvial, glacial or eolian origin. Soil moisture regime ranged from dry sands to wet shallow peat. In extreme cases, as near Drumheller, Alberta or in the Sprucewoods, Manitoba, native white spruce grew side by side with cacti. One noticeable feature of white spruce was its preference for north-facing slopes of river valleys. This characteristic allowed a deep penetration of the Boreal Forest into the Aspen Parkland.

In a number of locations the first white spruce encountered grew in nearly pure stands, providing a very sudden change from deciduous trees. This tendency was noted by Bird (1961), who attributed it to a succession directly from aspen to spruce. Perhaps the absence of other competing conifers allows white spruce to form pure stands and to occupy unusual habitats.

BLACK SPRUCE (MAP 2)

Black spruce formed a direct contrast to white spruce; it was restricted to very wet, peaty sites. It grew in pure stands or with scattered tamarack. Subordinate vegetation associated with

black spruce at even the most southerly occurrence was the same bog flora of heath (*Ericaceae*) and Sphagnum mosses that can be found in the Boreal Forest. The thickness of peat usually exceeded 2 m (6.5 ft), suggesting some antiquity for the black spruce-bog association.

TAMARACK (MAP 3)

Tamarack was also restricted to wet sites, growing in association with willow shrubs and sedges, or black spruce. Occasionally, white spruce was associated with it on wet, peaty soils.

JACK PINE AND LODGEPOLE PINE (MAP 4)

The first occurrence of jack pine was usually on sandy and gravelly soils, growing in pure, even-aged stands. Occasionally jack pine was found on dry ridges of loamy till materials, usually in association with stunted, shrubby aspen. Lodgepole pine occurred on similar sites, but it was more common on heavier soils than jack pine.

The pines are represented in the study area by jack pine in the east and by lodgepole pine in the west, with a zone of hybridization where the ranges of the two species overlap (Smithers 1962). This hybrid zone is centered on the North Saskatchewan River near Edmonton, Alberta (Map 4). Here the trees display a complete range of mixtures of the two pines, particularly in the morphology of cones, needles, and bark.

DISCUSSION

RANGE OF DISTRIBUTION

Most published information on the geographic range of coniferous trees on the Canadian Prairies is in the form of small-scale maps (cf. Hosie 1969, Little 1971) which are not suitable for comparison with the results of the present study. A comparison of species distribution shown in the Atlas of Alberta (Anon. 1969) and this survey shows that the range of the pines has been consistently overestimated in the Atlas, extending some 30-70 km (19-44 miles) beyond the range indicated by this survey. White spruce is shown in the Atlas as occurring some 20-50 km (12-31 miles) further in the Aspen Parkland than found by this survey in eastern Alberta. In central Alberta, however, white spruce can be found as much as 140 km (90 miles) beyond the range shown in the Atlas. There is reasonably good agreement between the ranges shown in the Atlas and by the survey for black spruce and tamarack, with the differences amounting to less than 30 km (18 miles).

Most of the Transitional Zone identified by this study falls within the Boreal Forest Region of Rowe (1972) in Manitoba and Saskatchewan where the southern limit of white spruce is very near the boundary between the Boreal Forest and the Forest-Grassland. In Alberta, however, the Transitional Zone lies almost completely in the Forest-Grassland Region.

EFFECTS OF CLIMATE ON DISTRIBUTION

The near coincidence of the southern distribution of the conifers investigated suggests that their general environmental requirements are similar and are met within a narrow zone, although their specific requirements (soil moisture, nutrients) may be quite different. The occurrence of most outliers can be explained in this context. The presence of all four conifers in the Riding Mountains is clearly related to orographic effects, as is the presence of white spruce and lodgepole pine on the Cypress Hills. In these areas the temperatures are lower and precipitation is higher than in the surrounding lowlands, making them similar to areas farther north. White spruce growing on north-facing slopes of river valleys in arid grasslands do not receive more precipitation than the surroundings; here the reduction in insolation and evaporation appears to allow the growth of spruce. The occurrence of white spruce and tamarack and the reported presence of black spruce (Bird 1927) in the Sprucewoods is probably related to soil moisture and nutrient conditions rather than to changed thermal regime.

The distribution of plants is a result of the interaction of the environment, chance history of migration, and disturbances with the various species (Rowe 1966), and a simple relationship between vegetation and climate rarely exists. Nevertheless, climate-influenced environmental factors are very important parameters governing plant distribution and growth; climate appears to be the

chief factor limiting the coniferous trees to the cooler and moister regions north of the Prairies. In spite of various efforts (Bryson 1966, Hare and Ritchie 1972), at the present time we cannot quantify these parameters. It may be that the distribution of coniferous trees is influenced by temperature and precipitation regimes not only on a short-term yearly basis, but also by the occurrence of unfavourable extreme conditions during the life of the trees.

EFFECTS OF MAN ON DISTRIBUTION

A distinct southern boundary of all conifer species suggests that this boundary was determined by natural parameters and not by anthropogenic (man-induced) factors. Clearing of forests is seldom complete; there is always some rough land, a lightly grazed pasture, or a woodlot left where conifers might survive. Forest fires may eliminate conifers locally for long periods of time, but in a very large area chances are that some localities will escape fires and the undisturbed vegetation will be preserved, even if in small patches. Cultivation, in fact, reduces the occurrence of large fires sweeping across the forests and hence favors white spruce.

The bog habitats of black spruce and tamarack were not suitable for agricultural development and were largely bypassed when clearing the land. Thus the southerly distribution of these species was not appreciably affected by man's activities. The virtual coincidence of these conifers with white spruce and pines gives further credibility to the distribution of spruce and pine as mapped in the present study.

CHANGES IN THE SOUTHERN BOUNDARY

The development of bogs is a slow process that can be measured in centuries. This suggests that the black spruce bogs have been established at the southern limits for a long time, and hence this limit forms a stable, long-term boundary. By inference, the southern limit of the other conifers is also stable since they require similar climatic conditions. This conclusion requires a re-examination of the claims that the prairie boundary and the Boreal Forest boundary have changed a great deal in the 20th century. Seton's old map, reproduced by Bird (1961), locates the deciduous-coniferous forest boundary in western Manitoba in 1905 more than 100 km (70 miles) northeast of the present boundary. Many white and black spruce trees now growing in the area mapped as deciduous by Seton in 1905 were found to be over 100 years old and were alive at the time of his investigation. Similarly, many black spruce bogs occur within the "Deciduous Forests"; these bogs must have existed 70 years ago. It seems that early records must be examined critically before accepting them at face value. Vegetation changes are occurring continuously, but at a much slower rate than suggested by Seton's map.

VEGETATION ZONES

The Aspen Parkland is defined by the absence of coniferous trees (Bird 1961), while the Boreal Forest contains a variety of coniferous species (Rowe 1972). The present study shows that a narrow zone separates these two regions; in this zone some but not

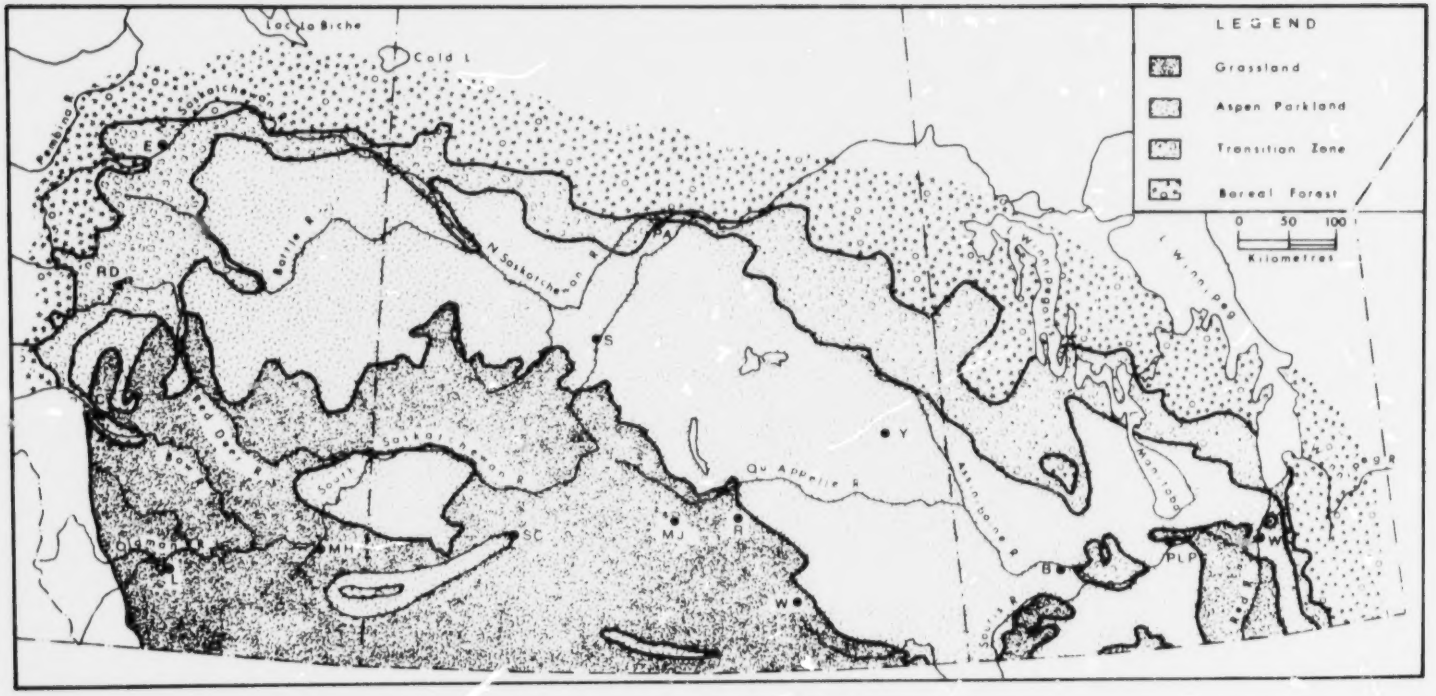

Figure 1. Major vegetation zones on the Canadian Prairies

all coniferous species are present. This zone can be termed the Parkland-Boreal Forest Transition Zone (Map 5). Since vegetation of this zone appears to have greater affinity toward the Boreal Forest than the Aspen Parkland, the zone could be considered to be a part of the Boreal Forest.

The northern boundary of the Aspen Parkland as given by Bird (1961) falls within this Transition Zone with remarkable accuracy. Accepting the southern boundary of the Aspen Parkland as shown by Bird (1961), the major vegetation zones of the Canadian Prairies can be depicted (Figure 1).

ACKNOWLEDGMENTS

Field observations were made in 1971 by N.B. Schultz, in 1972 by G.R. Hennessey, and in 1974 by M.W. Ali. The accurate, carefully executed survey they performed is the foundation of this report.

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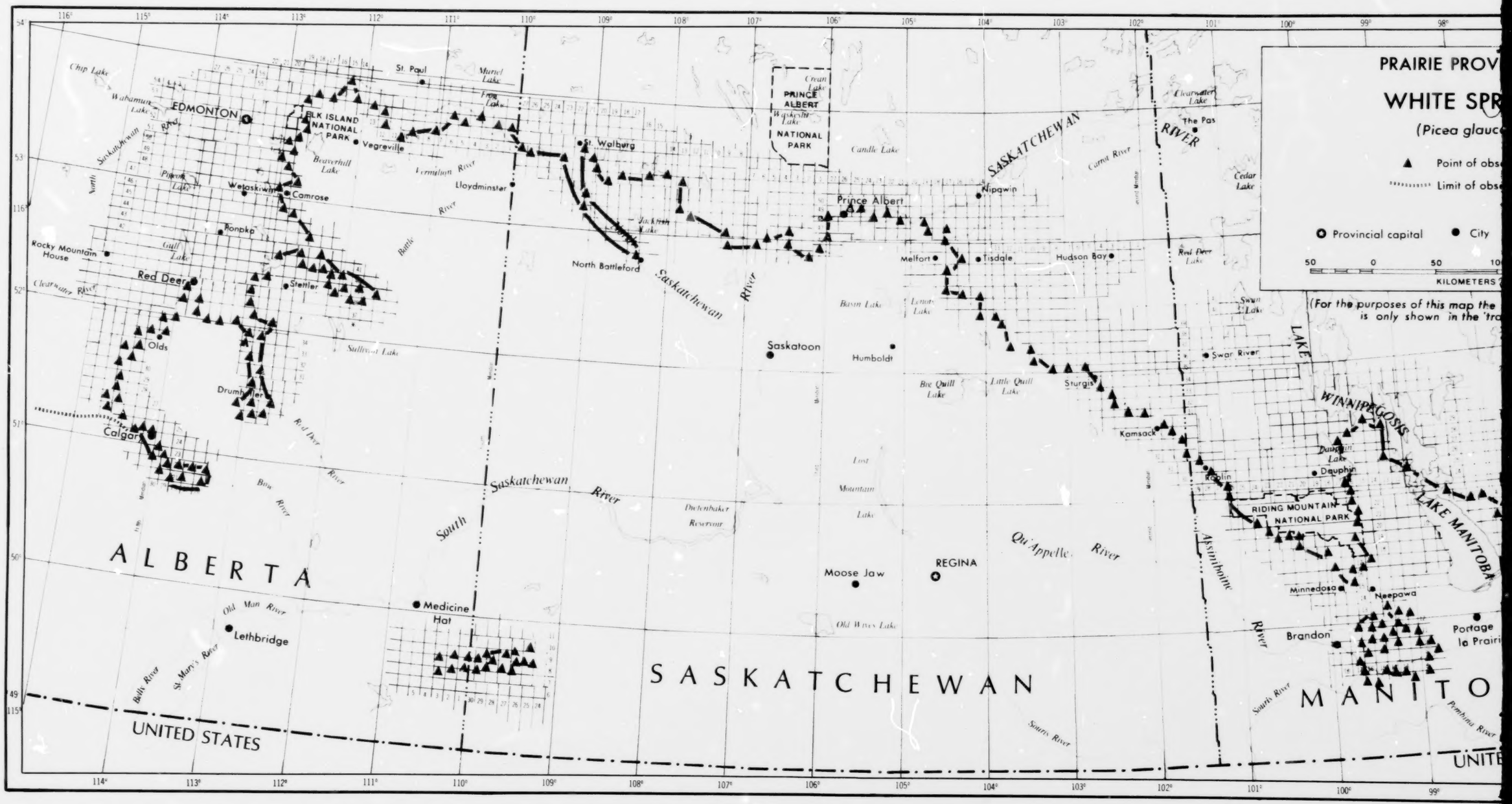
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Saskatoon
Prince Albert
North Battleford
Lloydminster
St. Paul
St. Walburg
Vegreville
Camrose
Wetaskiwin
Ponoka
Stettler
Olds
Drumheller
Rocky Mountain House
Red Deer
Melfort
Tisdale
Hudson Bay
Nipawin
The Pas
Humboldt
Sturgis
Kamsack
Yorkton
Melville
Dauphin
Minnedosa
Neepawa
Brandon
Portage la Prairi
Swan River
BLK ISLAND NATIONAL PARK
PRINCE ALBERT NATIONAL PARK
RIDING MOUNTAIN NATIONAL PARK
WINNIPEGOSIS
LAKE MANITOBA
Saskatchewan River
South Saskatchewan River
Qu'Appelle River
Assiniboine River
Red Deer River
Battle River
Vermilion River
Carrot River
Beaverhill Lake
Sullivan Lake
Basin Lake
Lost Mountain Lake
Old Wives Lake
Diefenbaker Reservoir
Chip Lake
Wabamun Lake
Pigeon Lake
Gull Lake
Jackfish Lake
Candle Lake
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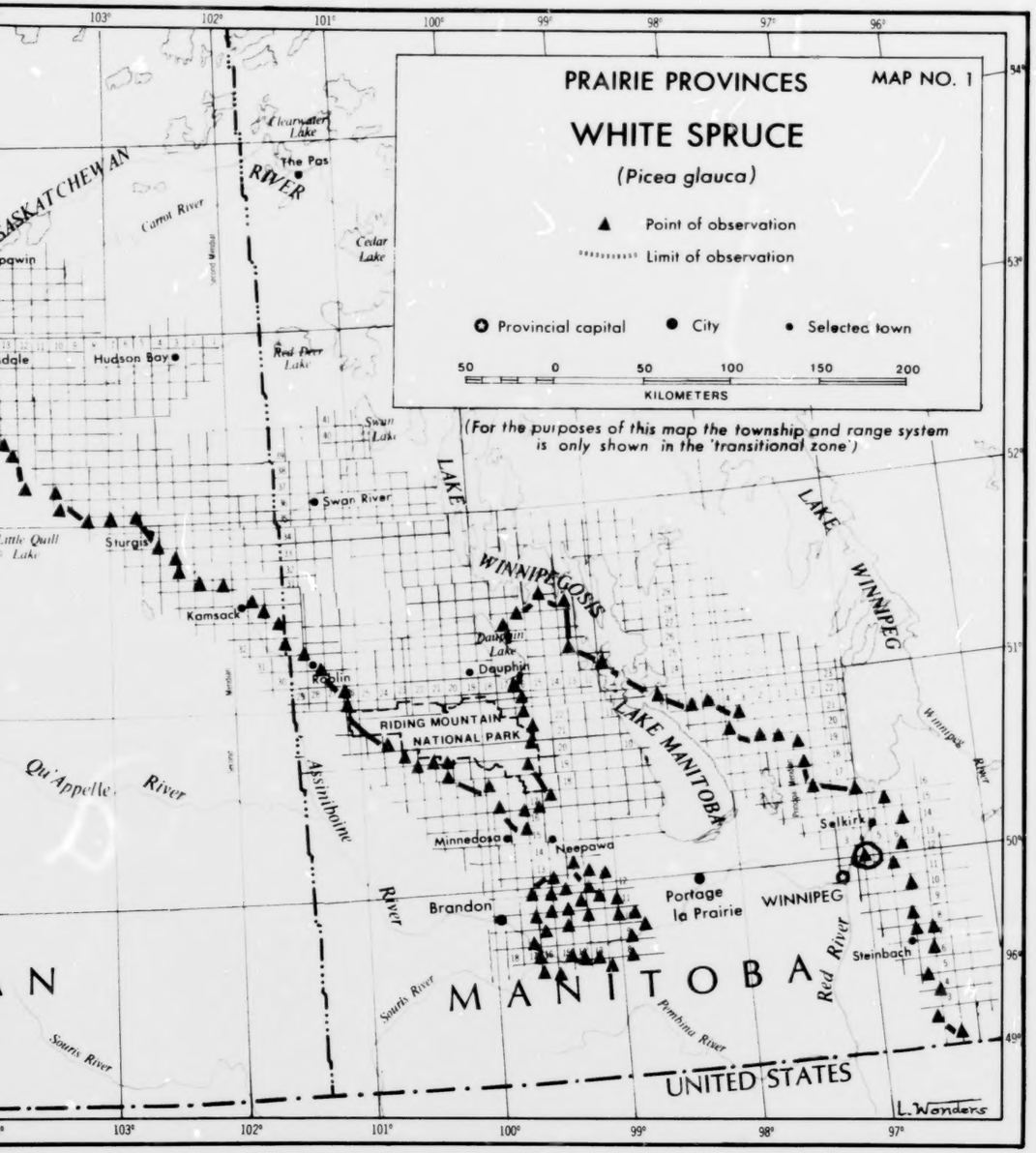
PRAIRIE PROVINCES
MAP NO. 1
WHITE SPRUCE
(Picea glauca)
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SASKATCHEWAN
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The Pas
RIVER
Carrot River
Cedar Lake
Hudson Bay
Red Deer Lake
Swan River
Sturgis
Little Quill Lake
Kamsack
Dauphin Lake
Dauphin
Roblin
RIDING MOUNTAIN NATIONAL PARK
Qu'Appelle River
Assiniboine River
Minnedosa
Neepawa
Brandon
Portage la Prairie
WINNIPEGOSIS
LAKE MANITOBA
LAKE WINNIPEG
WINNIPEG
Selkirk
Steinbach
Red River
Souris River
Pembina River
Winnipeg River
L. Wonders

Chip Lake
Wabamun Lake
EDMONTON
ELK ISLAND NATIONAL PARK
Vegreville
St. Paul
Muriel Lake
Iron Lake
St. Walburg
Beaverhill Lake
Vermilion River
Lloydminster
Pigeon Lake
Wetaskiwin
Camrose
Ronpka
Rocky Mountain House
Gull Lake
Battle River
Yorkton
North Battleford
Saskatchewan River
Clearwater River
Red Deer
Stettler
Olds
Sullivan Lake
Drumheller
Calgary
Red Deer River
Bow River
South Saskatchewan River
Diefenbaker Reservoir
Medicine Hat
Old Man River
Lethbridge
Belly River
St. Mary's River
UNITED STATES

PRAIRIE PROVINCES MAP NO. 2

BLACK SPRUCE

(Picea mariana)

▲ Point of observation

..... Limit of observation

○ Provincial capital ● City • Selected town

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(For the purposes of this map the township and range system is only shown in the 'transitional zone')

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MANITOBA

UNITED STATES

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Camrose
Wetaskiwin
Vegreville
St. Paul
St. Walburg
Lloydminster
North Battleford
Saskatoon
Humboldt
Prince Albert
Nipawin
Melfort
Tisdale
Hudson Bay
The Pas
Swan River
Kamsack
Sturgis
Dauphin
Roblin
Minnedosa
Neepawa
Brandon
REGINA
Moose Jaw
Rocky Mountain House
Jasper
ELK ISLAND NATIONAL PARK
PRINCE ALBERT NATIONAL PARK
RIDING MOUNTAIN NATIONAL PARK
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Saskatchewan River
North Saskatchewan River
South Saskatchewan River
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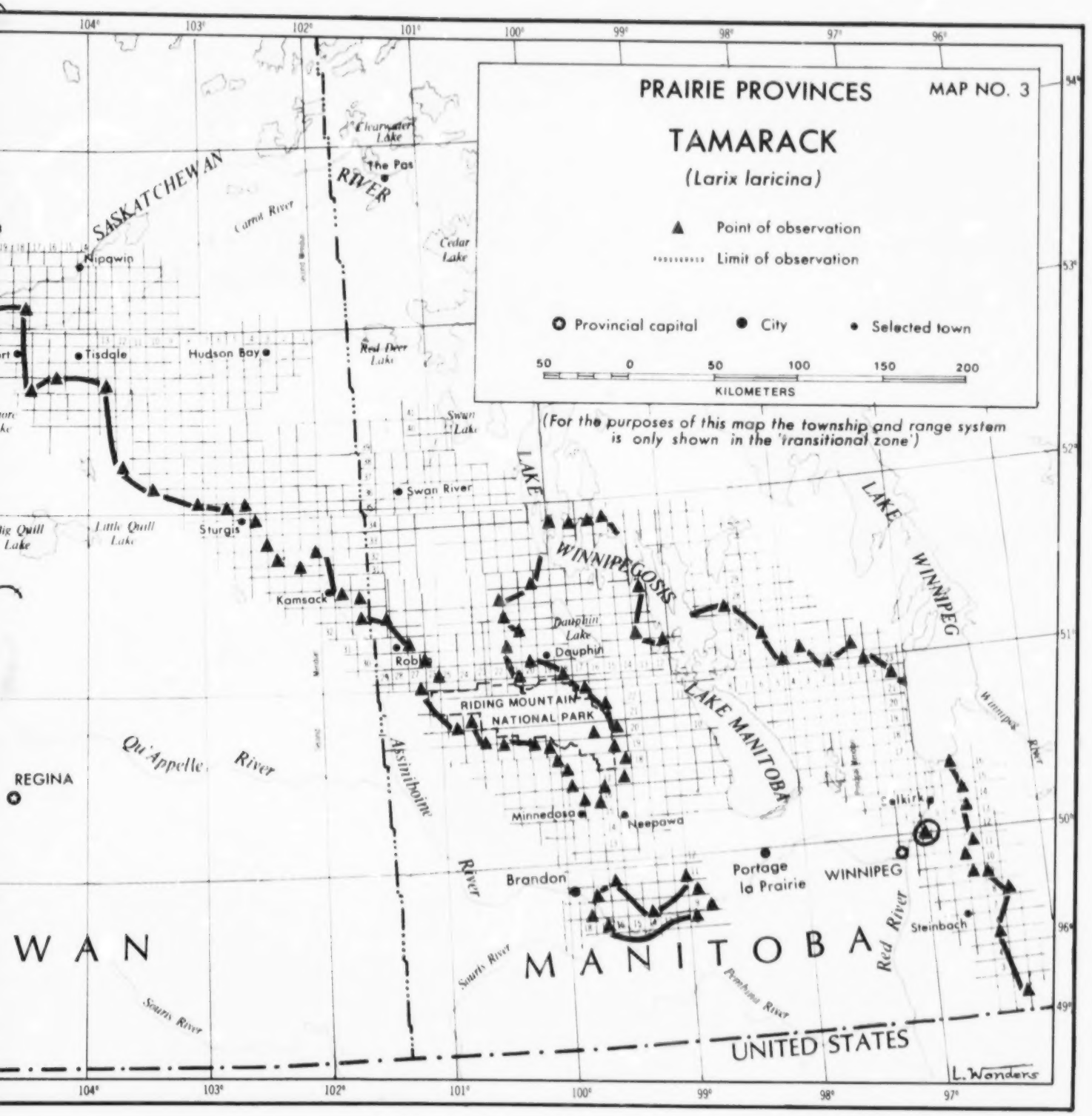
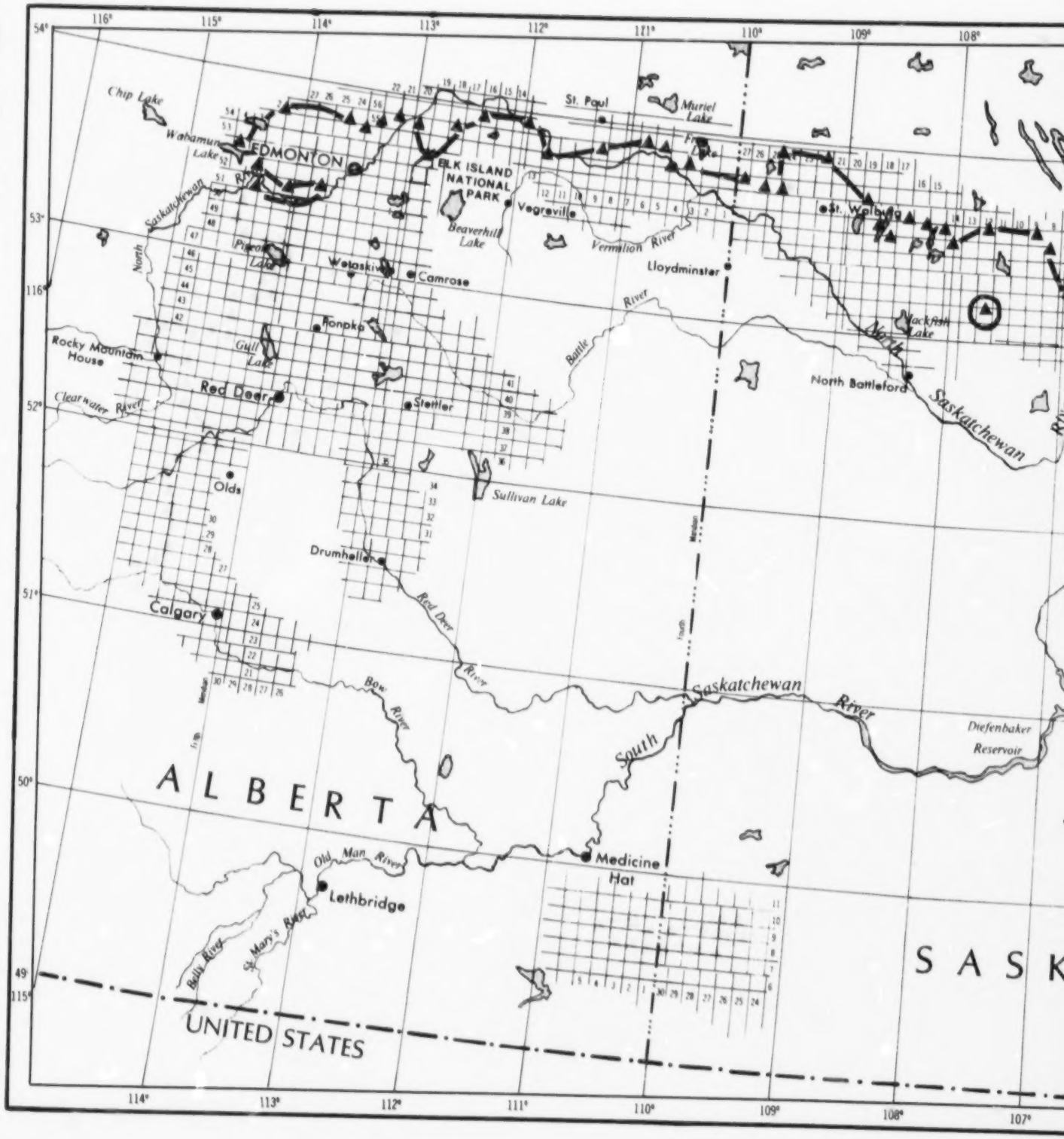
Beaverhill Lake
Vermilion River
Battle River
Clearwater River
Red Deer River
Bow River
Old Man River
Bella River
St. Mary's River
Sullivan Lake
Gull Lake
Pigeon Lake
Jackfish Lake
Muriel Lake
Frog Lake
Cream Lake
Candle Lake
Carrot River
Cedar Lake
Red Deer Lake
Swan Lake
Basin Lake
Lenore Lake
Big Quill Lake
Little Quill Lake
Lost Mountain Lake
Old Wives Lake
Diefenbaker Reservoir
Souris River
Dauphin Lake
Clearwater Lake


PRAIRIE PROVINCES
MAP NO. 3
TAMARACK
(Larix laricina)
Point of observation
Limit of observation
Provincial capital
City
Selected town
50 0 50 100 150 200
KILOMETERS
(For the purposes of this map the township and range system is only shown in the 'transitional zone')
SASKATCHEWAN
MANITOBA
UNITED STATES
Churchill
The Pas
Carrot River
Nipawin
Cedar Lake
Tisdale
Hudson Bay
Red Deer Lake
Swan Lake
Swan River
Big Quill Lake
Little Quill Lake
Sturgis
Kamsack
Rob
Dauphin Lake
Dauphin
RIDING MOUNTAIN NATIONAL PARK
LAKE WINNIPEGOSIS
LAKE WINNIPEG
LAKE MANITOBA
REGINA
Qu'Appelle River
Assiniboine River
Minnedosa
Neepawa
Brandon
Portage la Prairie
WINNIPEG
Selkirk
Steinbach
Souris River
Pembina River
Red River
Winnipeg River
L. Wonders


Chip Lake
Wahamun Lake
EDMONTON
St. Paul
Muriel Lake
ELK ISLAND NATIONAL PARK
Vegreville
Beaverhill Lake
Vermilion River
St. Walburg
Lloydminster
Pigeon Lake
Wetaskiwin
Camrose
Ponpkp
Gull Lake
Rocky Mountain House
Red Deer
Stettler
Battle River
North Battleford
Saskatchewan
Clearwater River
Olds
Sullivan Lake
Drumheller
Calgary
Red Deer River
Bow River
South Saskatchewan River
Diefenbaker Reservoir
ALBERTA
Old Man River
Medicine Hat
Lethbridge
Belly River
St. Mary's River
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115°
114°
113°
112°
111°
110°
109°
108°
107°

PRAIRIE PROVINCES

MAP NO. 4

JACKPINE AND LODGEPOLE PINE

(Pinus banksiana and Pinus contorta)

Point of observation

▲Jack Pine Lodgepole Pine

Limit of observation

(The range of the two pines overlap, resulting in a zone of hybrid pines)

Provincial capital City Selected town

50 0 50 100 150 200

KILOMETERS

(For the purposes of this map the township and range system is only shown in the 'transitional zone')

ALBERTA

SASKATCHEWAN

MANITOBA

UNITED STATES

UNITED STATES

EDMONTON

CALGARY

REGINA

WINNIPEG

ELK ISLAND NATIONAL PARK

PRINCE ALBERT NATIONAL PARK

RIDING MOUNTAIN NATIONAL PARK

LAKE MANITOBA

LAKE WINNIPEGOSIS

LAKE WINNIPEG

SASKATCHEWAN RIVER

Saskatchewan River

South Saskatchewan River

Red Deer River

Bow River

Old Man River

Battle River

Qu'Appelle River

Assiniboine River

Souris River

Pembina River

Red River

Carrot River

Diefenbaker Reservoir

St. Mary's Res.

Waskesiu Lake

Candle Lake

Lost Mountain Lake

Old Wives Lake

Basin Lake

Lenore Lake

Big Quill Lake

Little Quill Lake

Red Deer Lake

Cedar Lake

Swan River

Dauphin Lake

Winnipeg River

Lac du Bonnet

Selkirk

Steinbach

Portage la Prairie

Brandon

Minnedosa

Neepawa

Dauphin

Roblin

Kamsack

Sturgis

Melfort

Tisdale

Hudson Bay

Nipawin

Prince Albert

Saskatoon

Humboldt

Moose Jaw

Medicine Hat

Lethbridge

Drumheller

Olds

Stettler

Red Deer

Camrose

Wetaskiwin

Vegreville

Vermilion

Lloydminster

St. Paul

Muriel Lake

St. Walburg

Meadow Lake

Beaverhill Lake

Pigeon Lake

Wahamun Lake

Gull Lake

Sullivan Lake

Jackfish Lake

North Battleford

Clearwater Lake

The Pas

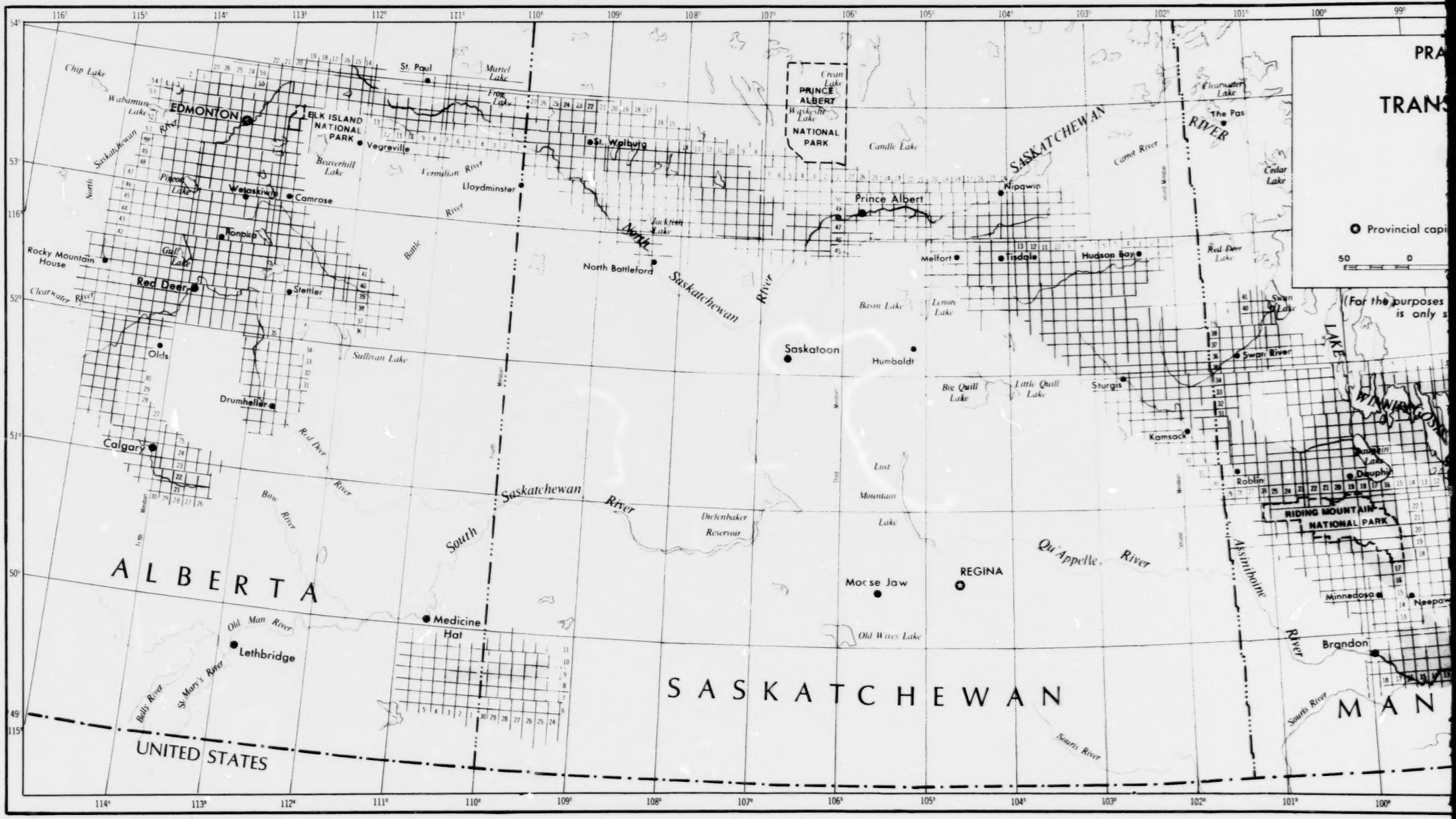
Second Meridian

Third Meridian

Fourth Meridian

Fifth Meridian

L. Wonders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Provincial capi
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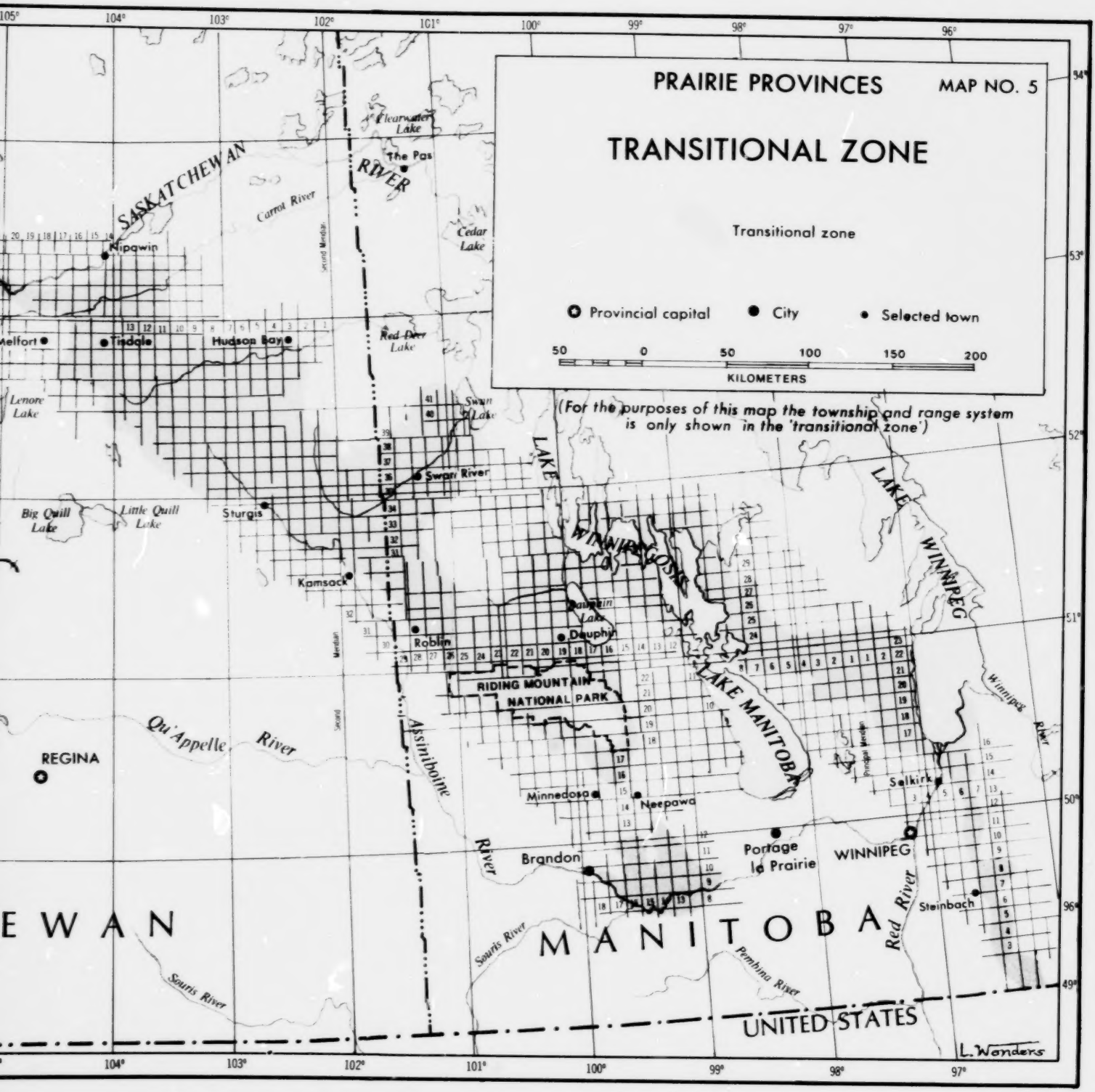
EDMONTON
ELK ISLAND NATIONAL PARK
PRINCE ALBERT NATIONAL PARK
RIDING MOUNTAIN NATIONAL PARK
St. Paul
Vegreville
St. Walburg
Lloydminster
North Battleford
Prince Albert
Nipawin
The Pas
Melfort
Tisdale
Hudson Bay
Saskatoon
Humboldt
Swan River
Sturgis
Kamsack
Roblin
Dauphin
Minnedosa
Brandon
Rocky Mountain House
Red Deer
Stettler
Olds
Drumheller
Calgary
Camrose
Wetaskiwin
Ponoka
Lacombe
Medicine Hat
Lethbridge
Moose Jaw
REGINA
Old Wives Lake
Diefenbaker Reservoir
Lake Lenore
Basin Lake
Big Quill Lake
Little Quill Lake
Candle Lake
Cedar Lake
Red Deer Lake
Swan Lake
Clearwater Lake
Cream Lake
Waskesiu Lake
Chip Lake
Wabamun Lake
Muriel Lake
Frog Lake
Beaverhill Lake
Pigeon Lake
Gull Lake
Jackfish Lake
Sullivan Lake
Lost Mountain Lake
Lake Winnipegosis
Lake Manitoba
SASKATCHEWAN RIVER
North Saskatchewan River
South Saskatchewan River
Battle River
Vermilion River
Clearwater River
Red Deer River
Bow River
Old Man River
Belly River
St. Mary's River
Carrot River
Assiniboine River
Qu'Appelle River
Souris River
Meridian 4th
Meridian 3rd
Meridian 2nd
ALBERTA
SASKATCHEWAN
MAN
UNITED STATES


PRAIRIE PROVINCES
MAP NO. 5
TRANSITIONAL ZONE
Transitional zone
Provincial capital
City
Selected town
50 0 50 100 150 200
KILOMETERS
(For the purposes of this map the township and range system is only shown in the 'transitional zone')
105° 104° 103° 102° 101° 100° 99° 98° 97° 96°
54° 53° 52° 51° 50° 49°
SASKATCHEWAN
MANITOBA
UNITED STATES
REGINA
Qu'Appelle River
Assiniboine River
SASKATCHEWAN RIVER
The Pas
Clearwater Lake
Carrot River
Cedar Lake
Nipawin
Melfort
Tisdale
Hudson Bay
Red Deer Lake
Lenore Lake
Swan Lake
Swan River
Big Quill Lake
Little Quill Lake
Sturgis
Kamsack
Dauphin Lake
Dauphin
Roblin
RIDING MOUNTAIN NATIONAL PARK
LAKE WINNIPEGOSIS
LAKE MANITOBA
LAKE WINNIPEG
Winnipeg River
Minnedosa
Neepawa
Brandon
Portage la Prairie
WINNIPEG
Selkirk
Steinbach
Red River
Souris River
Pembina River
L. Wonders